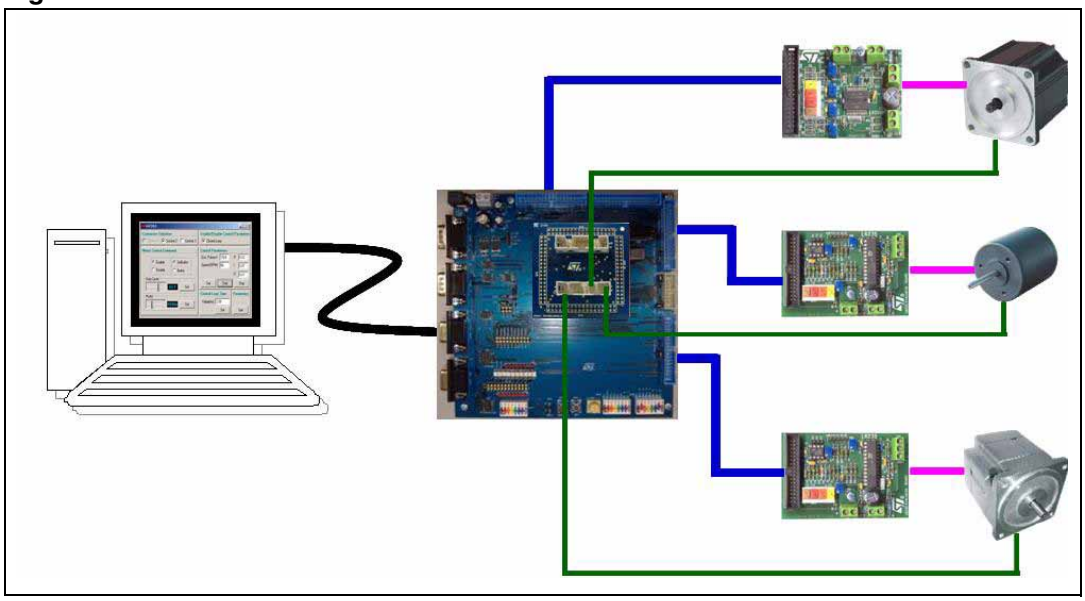
UM0289
User manual

eMotion: a motion control kit based on ST10F276

Introduction

This user manual describes the features of the eMotion Kit, and explains how use the kit to perform generic speed control of DC and BLDC motors.

Figure 1. eMotion kit



Key features

- GUI software (Windows XP OS-compatible)
- Control board MDK-ST10 (ST10F276 core, 16-bit DSP @ 64 MHz)
- Shielded interface board (for encoder feedback)
- powerSPIN boards (L6205 / L6235 eval)
- Configurable PID closed speed loop for up three motors DC or BLDC
- RS232 communication

Contents

1 Overview

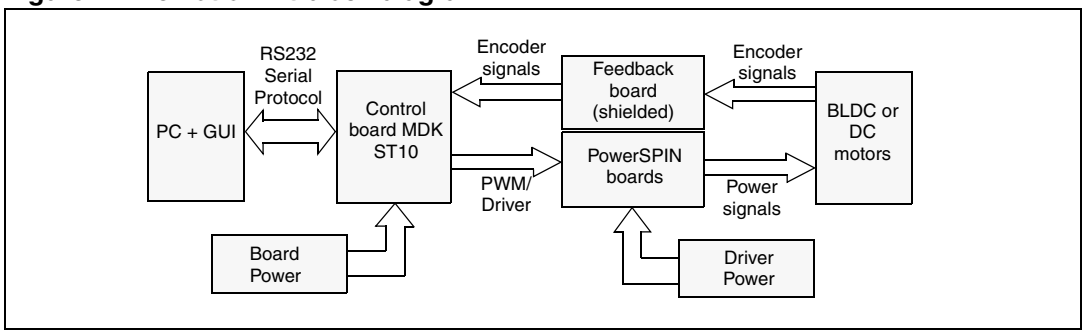
1.1 Getting started

eMotion is a motion control kit able to manage up to 3 motors (DC or BLDC) simultaneously, it can be used as starting point for the evaluation of control algorithms, motors and drivers.

The complete kit is composed of:

- Windows GUI (XP-compatible): a Multi-Windows software for managing, through a serial connection, the control of up three motors.
- MDK-ST10 board: control board based on microcontroller ST10F276 and three connectors compatible with a powerSPIN board (eval 62xx)
- Interface board: a board with two shielded connectors, to be stacked into the sockets of MDK-ST10 to allow motor feedback of encoder signals.
- powerSPIN boards: the eMotion kit can manage up to three motor driver boards based on L6205 (DMOS dual full bridge motor driver) and L6235 (DMOS fully integrated three-phase motor driver) chips, for DC and BLDC motors respectively.
- Firmware for open/closed loop operation: a complete source library is developed to manage the control of DC and BLDC motors in open loop mode (PWM and driver settings) and closed loop mode (speed regulation with encoder feedback) using 62xx eval boards.
- Protocol communication: a complete frame-based protocol is developed to allow the exchange of data with GUI via standard RS232 channel.

Figure 2. eMotion kit block diagram



It is possible via the GUI to interact with the ST10F276 control board (MDK-ST10) and generate open loop signals for up three DC or BLDC motors. The PWM frequency (17-30 kHz) and duty cycle (0-100%) can be managed together with driver signals such as enable/disable, brake/unbrake (BLDC) and forward/reverse (DC).

The closed loop operation can be performed in terms of motor speed with encoder feedback.

A complete PID (Proportional, Integrative, And Derivative) control algorithm is implemented.

The user can configure:

- the value of PID terms (from 0.01 to 100)
- the speed (from 1 to 3000 rpm)
- the control loop time (from 1 to 52 ms)
- the number of encoder pulses per revolution (1 to 65536)

Encoder feedback signals are directly managed by the ST10F276 through its dedicated peripherals.

In order to guarantee an optimum quality of encoder waveforms, a special adapter is included to shield the signals and to avoid interference (refer to *Section 2.3 on page 9* for further information).

2 Hardware

2.1 MDK-ST10

(Refer to the *MDK-ST10 User manual* (UM0288) for more detailed information)

The core of the eMotion Kit is the control board which is based on the ST10F276 microcontroller, in which all the driver board management routines are implemented.

Board key features:

- ST10F276 core (16-bit with DSP @ 64 MHz, 832 KB Flash,68 KB RAM)
- RS232
- RS485
- 2 CAN
- I^2C (3.3V and 5V)
- MC Connector
- 3 powerSPIN connectors
- VN808 board / GP connector
- All pin outs available

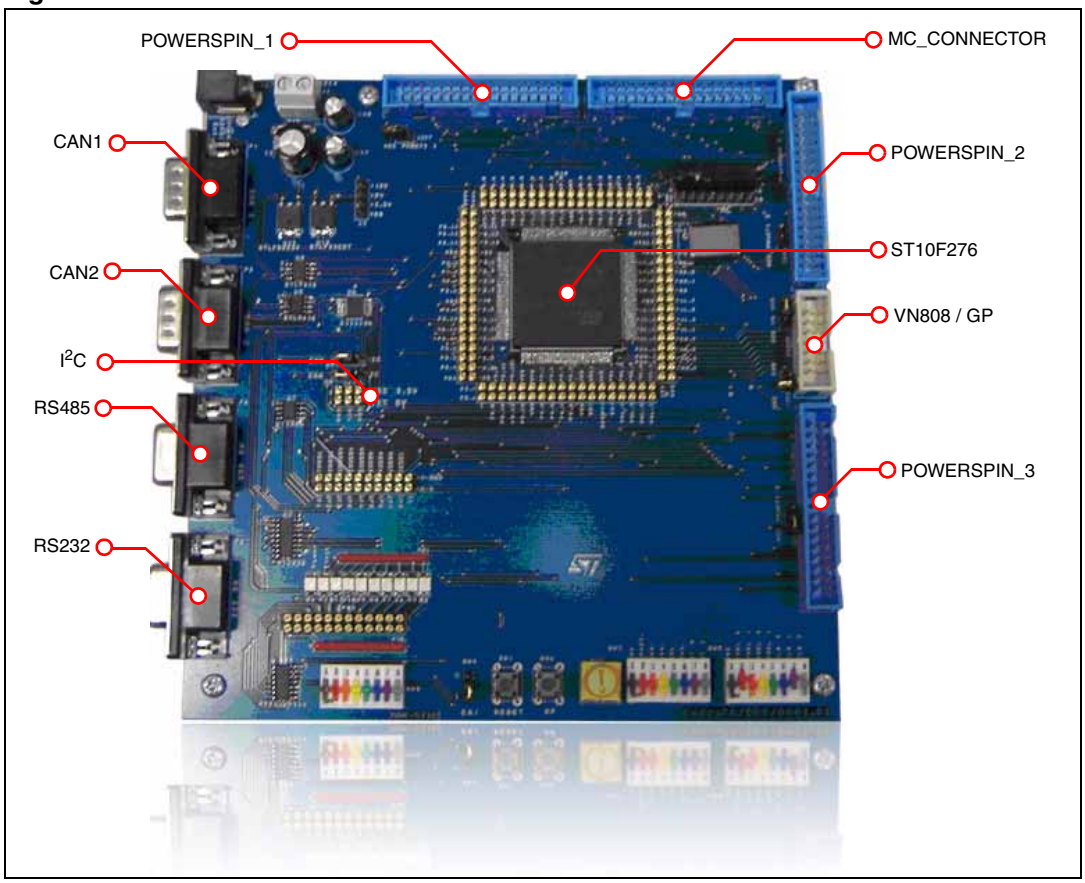
The board design allows the user to develop a high-end motion control system based on this 16-bit microcontroller. The features of this powerful device allow the integration of complex routines to create advanced motion control algorithms.

Referring on *Figure 2*, the eMotion kit uses the connectors PowerSpin_1, 2, 3 as indicated on the silkscreen of the board with the text "PractiSpin 1", "PractiSpin 2", "PractiSpin 3".

To allow the compatibility with powerSPIN evaluation boards, for each board connector is inserted a jumper (VCC PRACTI X, located close to the connector) that, if closed, provides a 5V power supply to the respective board.

Communication with a PC and GUI system is achieved via an RS232 channel through a standard DB9 female connector and using a standard RS232 cable.

Figure 3. MDK-ST10 board



Note: *Refer also to Section 5.1.2: Board configuration on page 23*

The default configuration of the board (once programmed) is:

- *EA jumper:* 1 (in order to obtain the fetch of the code from internal flash of microcontroller)
- *SW3 switches:* all OFF
- *SW5 switches:*
  - *Switch 2 (CSEL 0):* ON
  - *Switch 7 (CLK 1):* ON
  - *Other switches:* OFF
- *Selector J206:* "PRACTI" position (in order to connect micro lines to powerSPIN connectors)

These configurations impose a 60 MHz core clock frequency and leave port 6 of microcontroller free for I/0s (needed because P6.0=CS0 is used to manage powerSPIN boards)

To better understand how powerSPIN boards are managed by control board, *Table 1* provides a description of the powerSPIN connectors:

Table 1. PractiSPIN connectors description

PIN No.	PractiSPIN 1	PractiSPIN 2	PractiSPIN 3	Functionality
1	5V via Jumper J207 (VCC PRACTI 1)	5V via Jumper J208 (VCC PRACTI 2)	5V via Jumper J209 (VCC PRACTI 3)	-
2	P2_10	P2_11	P2_12	Interrupt
3	P5_5	P5_6	P5_7	ADC
4	P0L.0	P0L.1	P0L.2	GPIO
5, 6	NC	NC	NC	-
7	P1L.0	P1L.1	P1L.2	ADC
8	P0L.3	P0L.4	P0L.5	GPIO
9	NC	NC	NC	-
10	P0L.6	P0L.7	P6.3	GPIO
11, 13	NC	NC	NC	-
14	P6.0	P6.1	P6.2	GPIO
15, 16, 17, 18, 19	NC	NC	NC	-
20	P2.0	P2.1	P2.2	GPIO / Capcom
21	NC	NC	NC	-
22	P8.0	P8.1	P8.2	PWM / GPIO
23	GND	GND	GND	-
24, 25	NC	NC	NC	-
26	P7.4	P7.5	P7.6	GPIO / Capcom
27	NC	NC	NC	-
28	P7.0	P7.1	P7.2	PWM / GPIO
29, 30	NC	NC	NC	-
31	P2.13	P2.14	P2.15	GPIO / Capcom
32	P2.3	P2.4	P2.5	GPIO / Capcom
33	P1H.4	P1H.5	P1H.6	GPIO / Capcom
34	NC	NC	NC	-

2.2 PowerSPIN boards

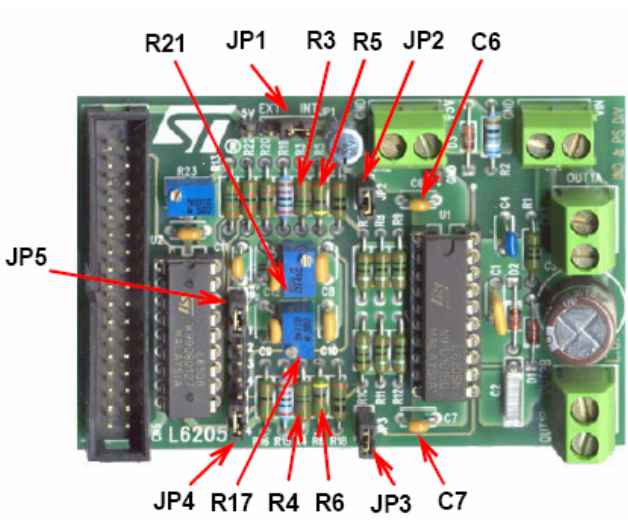
eMotion kit can manage up to three boards based on monolithic driver of L62xx family. This first release of system works with DC and BLDC drivers so with boards L6205 and L6235 but also with similar boards for the same motors.

2.2.1 L6205 Eval board (DC Motor)

(refer to application note *AN1762* and the *L620x datasheet* for more details)

eMotion kit can manage the evaluation board based on DMOS full bridge ICs (L6205,L6206,L6207).

Figure 4. Eval 6205N board



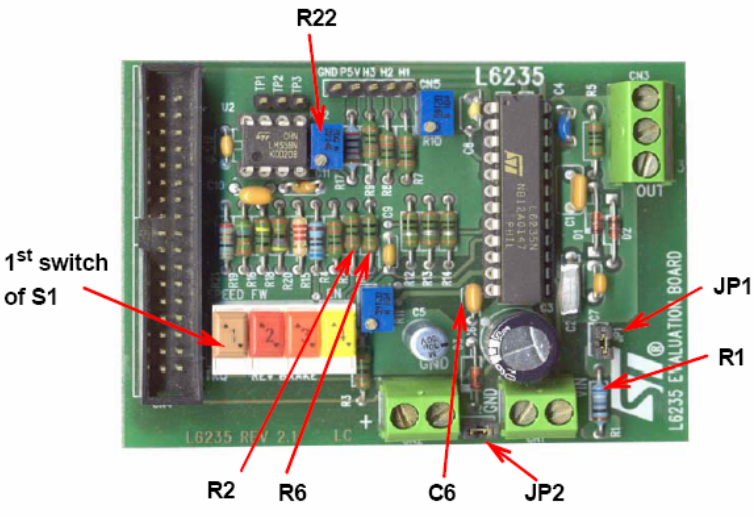
Refer to *Section 5.1.2: Board configuration on page 23* for a description of the board configuration using eMotion.

2.2.2 L6235 Eval board (BLDC Motor)

(refer to application note *AN1625* and the *L6235 datasheet* for more details)

eMotion kit can manage the evaluation board based on L6235 three phase brushless DC motor.

Figure 5. Eval 6235 board



Refer to *Section 5.1.2: Board configuration on page 23* for a description of the board configuration using eMotion.

2.3 Feedback board

In order to interface the control system with encoder signals coming from motors, a special board, with two 20 pins connectors in the top side, is used (Feedback board).

This is a stackable board and has to be inserted using the four 36-pin connectors around the microcontroller in the MDK-ST10 board. The insertion orientation is indicated with a dot in a corner of the board (corresponding to pin 1 of the ST10 MCU)

The two connectors (Conn1 J3, Conn2 J4), used to allow the encoder feedback, are shielded with the pair of pins connected to GND.

The dimensions of this board are about 6.5 x 6.5 cm. The following tables show the pin assignments for each connector.

Table 2. Conn1 Feedback board

Conn.1	MDK-ST10 Pin	Functionality
1	P3.7	T2IN (encoder_1 A)
2	GND	-
3	P5.15	T2EUD (encoder_1 B)
4	GND	-
5	P3.6	T3IN (encoder_2 A)
6	GND	-
7	P3.4	T3EUD (encoder_2 B)
8	GND	-
9	P3.5	T4IN (encoder_3 A)
10	GND	-
11	P5.14	T4EUD (encoder_3 B)
12	GND	-
13	P2.6	CC16 (capture / GPIO)
14	GND	-
15	P1L.3	GPIO / ADC In
16	GND	-
17	P1L.4	GPIO / ADC In
18	GND	-
19	+5V	-
20	GND	-

Table 3. Conn2 Feedback board

Conn.2	MDK-ST10 Pin	Functionality
1	P1L.5	GPIO/ ADC In
2	GND	-
3	P2.7	CC7 (capture / GPIO)

Conn.2	MDK-ST10 Pin	Functionality
4	GND	-
5	P1L.6	GPIO / ADC In
6	GND	-
7	P1L.7	GPIO / ADC In
8	GND	-
9	P1H.0	GPIO
10	GND	-
11	P1H.7	CC27 (capture / GPIO)
12	GND	-
13	P1H.1	GPIO
14	GND	-
15	P1H.2	GPIO
16	GND	-
17	P1H.3	GPIO
18	GND	-
19	+5V	-
20	GND	-

Figure 6. Feedback board schematic

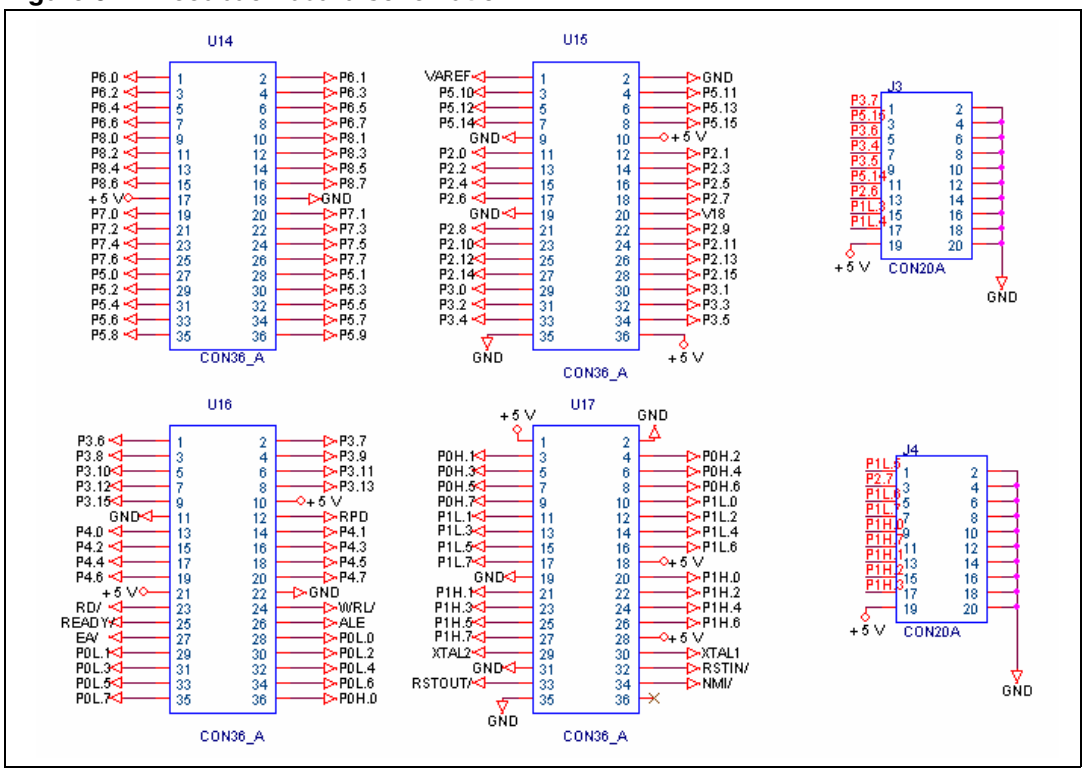
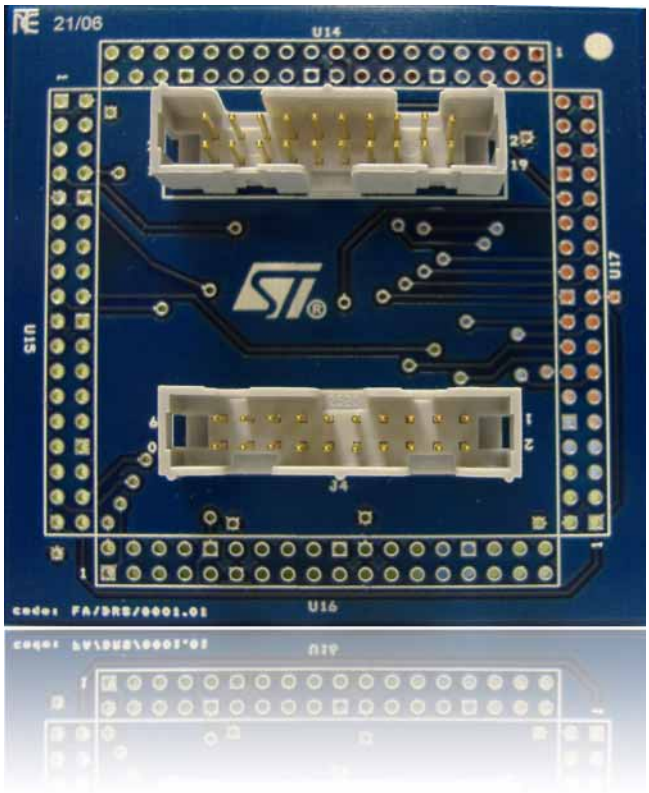


Figure 7. Feedback board - TOP



In order to report the feedback of motors, a 20-pin flat cable could be used. The first connector can be used for an incremental encoder as the timer pins are used for incremental interface mode. The second connector can be used for absolute encoder feedback where the GPIO and capture pins are used.

Note: The system allows the feedback of encoder signals (A and B channels) for each motor,

Signals must be squared and with the right logic level (0 and 5V). When necessary, refer to the datasheet of the encoder used. If needed, pull-up the encoder signals (not provided with encoder kit).

3 PC software

The parameters of eMotion system can be configured through a Windows-based GUI (eMotion GUI), that interacts with the control board via an RS232 straight cable.

The following paragraphs provide a description of all the software features.

3.1 eMotion GUI

Refer to *Section 5.1.1: Installing eMotion GUI on page 23* for the installation procedure.

After start-up of the eMotion GUI, a series of menu functions are available to the user:

File:

Connect: Open the "Serial Port Selection" window, from which it is possible to select the serial port to open the communication between the PC and the MDK-ST10 board

Disconnect: Close the connection between the PC and the MDK-ST10 board.

New: Open a new 6205 or 6235 window (for a DC or BLDC motor respectively)

Log Window: Open the Log Window. In this window it is possible to see the communication data as a hexadecimal value sent to the MDK-ST10 board

Exit: Exit the program

View:

Toolbar: Display or hide the toolbar

Status Bar: Display or hide the status bar in the bottom-right corner of the main window

Help

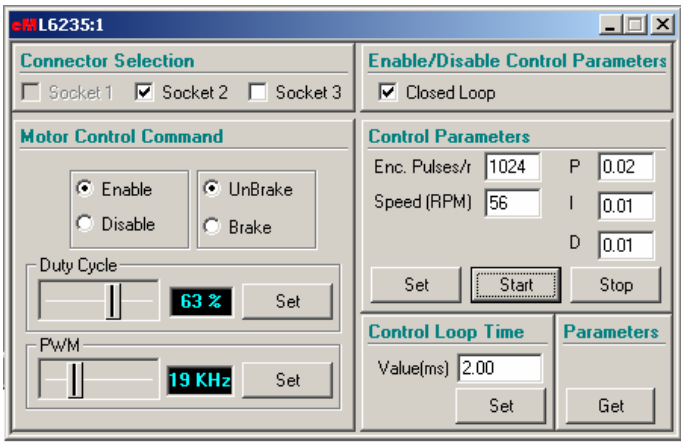
Help Topics: Open the Help Topics

About: Displays eMotion Project credits

3.1.1 EVAL 6235 window

The 6235 window allows the user to drive a BLDC motor through the EVAL6235 board. After starting eMotion, click on the **6235 window** icon or choose **New** - **6235 window** from the File menu. A new 6235 window opens.

Figure 8. 6235 window



The *Connector Selection* panel shows the connector of the MDK-ST10 with which the EVAL6235 can be connected (some connector selections could be disabled if the connector is used by other windows). The left part of this window allows the user to control a BLDC motor in open loop mode. The right part of the window allows the user to perform a PID speed closed loop control with encoder feedback.

The *Motor Control Command* panel is always enabled, while the *Control Parameters* and *Control Loop Time* panels are disabled when the Closed Loop check button is not checked. In each case the **Get** button is always enabled.

Motor Control Command panel:

- *Enable:* Enables the 6235 driver. This command switches ON all Power MOSFETs of the driver (pin EN high).
- *Disable:* Disables the 6235 driver. This command switches OFF all Power MOSFETs of the driver (pin EN low).
- *Unbrake:* Sets the pin BRAKE high of the 6235 and enables the normal mode (six step control strategy).
- *Brake:* Sets the pin BRAKE low of the 6235. This command switches ON all High Side Power MOSFETs, implementing the Brake Function.
- *Duty Cycle Set:* This slider allows the user to set the duty cycle of the PWM generated by the ST10 as input for the FWD/REV pin of the 6235 driver. Values between 0 and 50% cause the rotation of the motor in one direction, while values between 50% and 100% cause the rotation of the motor in the other direction. A 50% value corresponds to no motor rotation.

Note: The real direction (clockwise or counterclockwise) depends on the connection between the 6235 and the motor.

- *PWM set:* This slider allows the user to change the frequency of the PWM generated by the ST10. The allowed values go from a minimum of 17 kHz to a maximum of 30 kHz. (with 1 kHz steps)

Note: At system startup the default values are: disable, brake, PWM duty cycle 50%, PWM frequency 17 kHz.

Enable/Disable Control Parameters panel:

- *Closed Loop:* This check control enables/disables the text boxes and push buttons of the *Control Parameters* and *Control Loop Time* panels.

Control Parameters panel:

This panel allows the user to perform a PID speed closed loop control with encoder feedback. The user must fill the following text boxes and then press the **Set** button in order to set the control parameters:

- *Enc. Pulses/r:* The number of pulses per revolution of motor encoder.
- *Speed:* Speed of the motor expressed in RPM. Allowed values go from 0 to 3000 rpm (steps 1 rpm).
- *P:* Proportional gain of the PID control. Allowed values go from 0 to 100, in steps of 0.01.
- *I:* Integral gain of the PID control. Allowed values go from 0 to 100, in steps of 0.01.
- *D:* Derivative gain of the PID control. Allowed values go from 0 to 100, in steps of 0.01.
- *Set:* Set the control parameters.

Note: If values out of range are inserted in one or more text boxes, a pop-up window will appear indicating that at least one value is out of range.

- *Start:* Start the PID speed closed loop control. The rotation of the motor remains the same of the motor before starting the control.
- *Stop:* Stop the PID speed closed loop control. The motor will rotate with a speed accordingly to the duty cycle calculated in the last control routine before stopping.
- *Get:* This command returns the status of the control parameters and of the control loop time actually memorized in the MDK-ST10 board.

Control loop time:

This text box allow the user to insert the value of control loop time (in case of closed loop operation); the range of this parameter is from 1 to 52 ms (with 200 us steps)

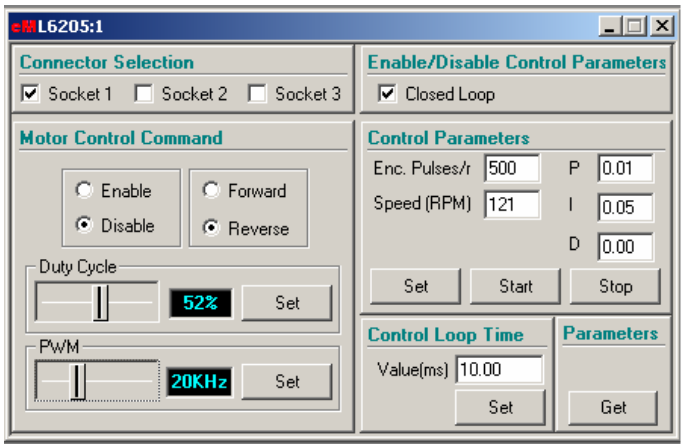
Note: For control loop time is intended the frequency of adjustment of PWM duty cycle (according to PID action) in order to reach the speed reference.

3.1.2 EVAL 6205 window

The 6205 window is designed to allow the user to drive a DC motor through EVAL6205. After starting eMotion click on the *6205 window* icon or choose *New - 6205 window* from the File menu. A new 6205 window is now opened.

Note: The functions of this window are the same of 6235 window, except for the motor control panel.

Figure 9. 6205 window



The *Connector Selection* panel shows the connector of the MDK-ST10 with which the EVAL6205 can be connected (some connector selections could be disabled if the connector is used by other windows). The left part of this window allows the user to control a DC motor in open loop mode. The right part of the window allows the user to perform a PID speed closed loop control with encoder feedback.

The *Motor Control Command panel* is always enabled, while the *Control Parameters* and *Control Loop Time* panels are disabled when the Closed Loop check button is not checked. In each case the **Get** push button is always enabled.

Motor Control Command panel:

- *Enable:* Enables the 6205 driver. This command switches ON all Power MOSFETs of the driver (pin EN high).
- *Disable:* Disables the 6205 driver. This command switches OFF all Power MOSFETs of the driver (pin EN low).
- *Forward:* This command set low the pin IN1 of the EVAL6205 (pin IN1A of 6205 driver).
- *Reverse:* This command set high the pin IN1 of the EVAL6205 (pin IN1A of 6205 driver).
- *Duty Cycle Set:* This slider allows the user to set the duty cycle of the PWM generated by the ST10 as input for the IN2 of the EVAL6205 (pin IN2A of the 6205 driver).The direction of rotation of the motor depends on the Forward/Reverse radio buttons. If Forward (Reverse) radio button is checked a value of PWM of 0% (100%) stops the motor while a value of PWM of 100% (0%) runs the motor at maximum velocity.

Note: The real direction (clockwise or counterclockwise) depends on the connection between the 6205 and the motor.

- *PWM set:* This slider allows the user to change the frequency of the PWM generated by the ST10. The allowed values go from a minimum of 17 kHz to a maximum of 30 kHz (steps 1 kHz).

Note: At systems startup the default value are: disable, forward, PWM duty cycle 50%, PWM frequency 17 kHz.

Enable/Disable Control Parameters panel:

Refer to *Section 3.1.1: EVAL 6235 window on page 12*.

Control Parameters panel:

Refer to *Section 3.1.1: EVAL 6235 window on page 12*.

Control loop time:

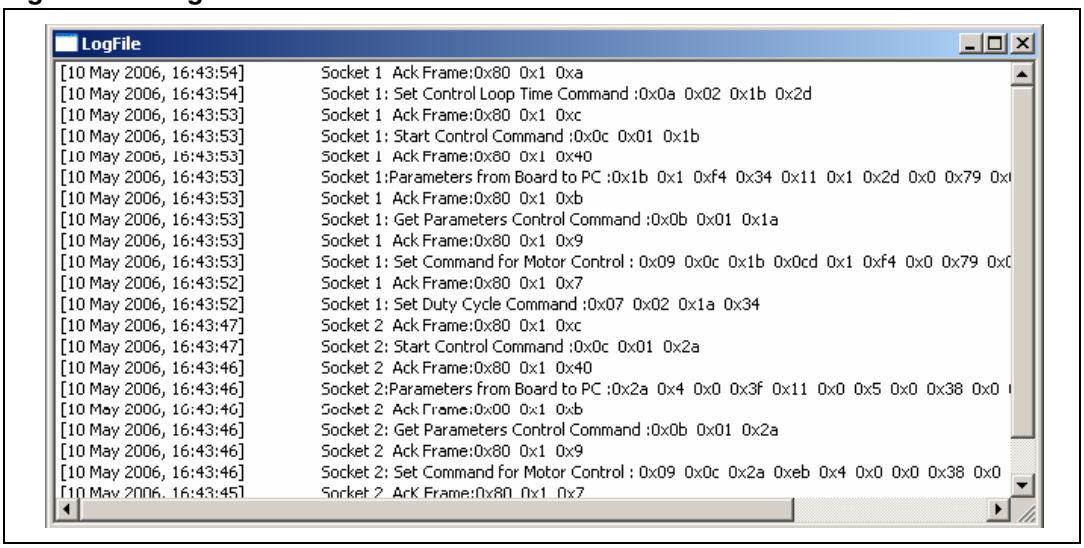
Refer to *Section 3.1.1: EVAL 6235 window on page 12*.

3.1.3 Log window

Using the log window is possible to view the frames sent and received by the GUI (to check the state of communication with the board).

A text string is shown explaining the command and also the hexadecimal value of the command (refer to *Section 4.1: Communication protocol on page 17*).

Figure 10. Log window



4 ST10 firmware

The firmware to manage the eMotion system is organized in two separate modules:

- *Communication module*: able to exchange data with the PC-GUI using a structured protocol.
- *Control module*: able to perform the open and closed loop operation on three motors and communicates with the first module.

Note: All the firmware is developed, in standard C language, using tasking toolchain v 8.5 from Altium.

4.1 Communication protocol

The serial protocol used for communicate with PC-GUI is a frame based protocol, with a baud rate of 115200, 8-bit data length, no parity check, 1 bit stop.

The frame has a variable length, with a CRC field. A mechanism of acknowledgement for each command is implemented.

Figure 11. Frame protocol

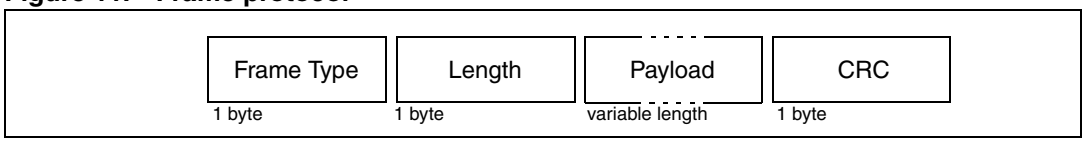


Figure 11 shows the general frame format on which the communication is based, the CRC is a field of 1 byte length computed with this formula:

16_Total_Length = (16_bit) (FRAME_TYPE + LENGTH + DATA)

CRC = (8_bit) (High_Byte(16_Total_Length) + Low_Byte(16_Total_Length))

Table 4 shows the general description of the frames.

Table 4. Frame description

Frame name	Description	Frame Type	Length	Direction	Type
Connect	Open connection	0x00	0	PC-MDK ST10	Command
Enable_Motor	Enable motor drive	0x01	1	PC-MDK ST10	Command
Disable_Motor	Disable motor drive	0x02	1	PC-MDK ST10	Command
Brake_Motor	Enable brake motor drive	0x03	1	PC-MDK ST10	Command
Unbrake_Motor	Disable brake motor drive	0x04	1	PC-MDK ST10	Command
Forward_Motor	Set forward motor direction (6205 motor drive)	0x05	1	PC-MDK ST10	Command

Frame name	Description	Frame Type	Length	Direction	Type
Reverse_Motor	Set reverse motor direction (6205 motor drive)	0x06	1	PC-MDK ST10	Command
Set_PWM	Set duty cycle of PWM	0x07	2	PC-MDK ST10	Command+Data
Set_Freq_PWM	Set frequency of PWM	0x08	2	PC-MDK ST10	Command+Data
Set_PID_Control	Set the PID and speed values	0x09	12	PC-MDK ST10	Command+Data
Set_Control_Loop Time	Set the time for executing the closed control loop	0x0A	2	PC-MDK ST10	Command+Data
Get_Parameters	Get the control parameters.	0x0B	1	PC-MDK ST10	Command
Start_Control	Start control loop	0x0C	1	PC-MDK ST10	Command
Stop_Control	Stop control loop	0x0D	1	PC-MDK ST10	Command
Get_Latest_Error	Get Latest error occurred	0x0E	0	PC-MDK ST10	Command
Send_Parameters	Transmission of the parameters values	0x40	15	MDK ST10-PC	Data
Send_Latest_Error	Send latest error occurred	0x41	1-50	MDK ST10-PC	Data
ACK	Confirm the correct reception of a frame	0x80	1	MDK ST10-PC PC-MDK ST10	Acknowledgment

The length field indicated the number of bytes in the payload.

In each frame (with length greater than 0) the first byte of the payload indicates the association connector-powerspin board (except "Send_Latest_Error") (see *Table 5*):

Table 5. Connector-Eval62xx

Byte	Value
0x1A	First connector with eval 6235
0x1B	First connector with eval 6205
0x2A	Second connector with eval 6235
0x2B	Second connector with eval 6205

Byte	Value
0x3A	Third connector with eval 6235
0x3B	Third connector with eval 6205

ACK timeout is fixed at 10 ms, both for the PC and ST10, and the payload of the "ACK" frame is the command code to be acknowledged.

"Set_PID_Control" (0x09) is the frame used for setting the specific values of each control loop, the contents of this frame is shown in the table below.

Table 6. Table 6 - Set_PID_Control payload

Payload byte order	Field	Description
1	Motor Connector	Association connector-powerSPIN board
2	Driver	Byte for reserved use, indicating the kind of driver (0xCD for a6205,0xEB for a 6235)
3-4	Encoder	2 Bytes indicating number of pulse for revolution of motor encoder.
5-6	Speed	2 Bytes indicating the reference speed of motor (range 1-3000 rpm)
7-8	P	2 Bytes indicating the proportional gain of the speed control (range 1-1000, with a firmware scaling)
9-10	I	2 Bytes indicating the integral gain of the speed control (range 1-1000, with a firmware scaling)
11-12	D	2 Bytes indicating the derivative gain of the speed control (range 1-1000, with a firmware scaling)

"Set_Control_Loop time" (0x0A) is a frame used to set the control loop time of each motor control, according to the table below.

Table 7. Set_Control loop time payload

Payload byte order	Field	Description
1	Motor Connector	1 Byte indicating which powerSPIN board is connected to a specific connector.
2	Time	Byte indicating the control loop time (number of 200us steps to be added to the basic control loop of 1ms).

"Send_Parameters" (0x40) is a particular frame used to send the status of all system parameters to the PC, the contents of this frame is shown in *Table 8*.

Table 8. Send_Parameters contents

Payload byte order	Field	Description
1	Motor Connector	1 Byte indicating which powerSPIN board is connected to a specific connector.
2-3	Encoder	2 Bytes indicating the number of pulses for revolution of motor encoder.
4	PWM %	Byte indicating the duty cycle value of PWM (range: 0-100)
5	PWM Freq.	Byte indicating the frequency PWM (range: 17-30)
6	Time control loop	Byte indicating the control loop time (number of 200us steps to be added to the basic control loop of 1ms).
7	Status	Byte indicating if the control is enabled (0 or 1)
8-9	Speed	2 Bytes indicating the reference speed of motor (range 1-3000 rpm)
10-11	P	2 Bytes indicating the proportional gain of the speed control (range 1-1000, with a firmware scaling)
12-13	I	2 Bytes indicating the integral gain of the speed control (range 1-1000, with a firmware scaling)
14-15	D	2 Bytes indicating the derivative gain of the speed control (range 1-1000, with a firmware scaling)

"Send latest error" (0x41) is a particular frame in which the payload is formed by a text string indicating the last error occurred, typical values are shown below.

Table 9. Error strings

String Types
No error
CRC not valid
Command not valid
Command not executable
Motor error
Value out of range

A series of protocol frames, used for communication, are provided in *Table 10*.

Table 10. Frame examples

Frame Description	Value (Hex)
Connect	00-00-00
Enable 6235 driver on powerSPIN connector 1	01-01-1A-1C
Brake 6205 driver on powerSPIN connector 3	03-01-3B-3F
ACK for a Forward command	80-01-05-86

Frame Description	Value (Hex)
Set PWM% to 22% for 6235 driver on connector 2	08-02-2A-16-4A
Set 2ms of control loop time for a 6205 driver on connector 2	0A-02-2B-05-3C
Set control for a DC motor with a 1024/revolution encoder, connected to the first connector. Set the speed reference to 100 rpm with control parameters of P=0.04,I=0.02,D=0.01	09-0C-1B-CD-04-00-00-64-00-04-00-02-00-01-6D
Receive the parameters of connector 3 with a BLDC motor with 500/revolution encoder controlled at 200 rpm with P=0.60, I=0.02,D=0.00 and control loop of 1.2 ms. With actual PWM signal 10% / 22 Khz	40-0F-3A-01-F4-00-0A-16-02-01-00-C8-00-3C-00-02-00-00-A9

4.2 Control algorithm

Communication layer after the reception and checking of a complete frame puts the microcontroller in an execution state in which the right control layer function is involved.

The management of open loop signals is executed with functions that directly act in the register of PWM signals or through the pins for the right generation of connector signals.

Closed loop operations, are instead managed through three independent ISR where the reload timing depends on the closed loop time of the specific control.

The speed reference is expressed in terms of encoder pulses, counted in the closed loop timing imposed, so each ISR works with the actual values of encoder inputs and with PWM duty cycles to perform a PID action for reach the right value of encoder reference.

Figure 12. Algorithm block diagram

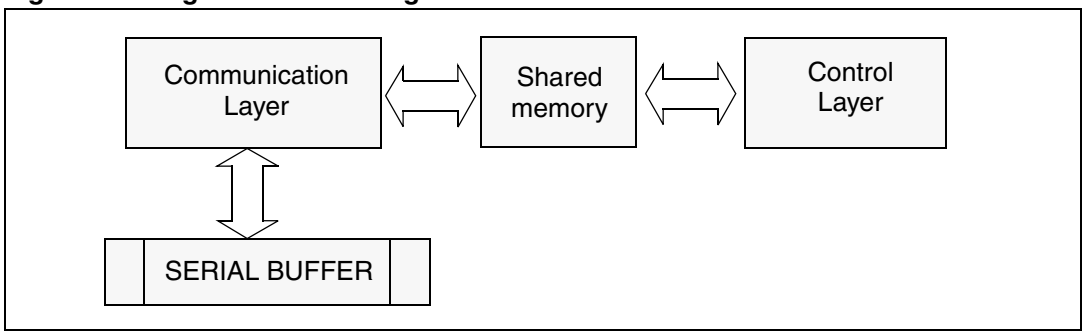


Figure 12 shows how the two modules interact (through shared memory) to perform eMotion operations.

The PID algorithm implemented is approximated with the following formula:

$$u(n) = P \cdot e(n) + I \cdot \sum_{K=1}^{n} e(k) \cdot T + D \cdot \frac{e(n) - e(n-1)}{T}$$

where:

u(n): is the output at time n (related to the duty cycle sent to driver)

P, I, D: are respectively proportional gain, integrational gain and derivative gain.

e : is the error (in terms of encoder pulses)

T : is the sample time

5 Using eMotion

5.1 Evaluate eMotion kit

In order to start eMotion system all this items should be available:

- eMotion GUI
- MDK-ST10 board
- Feedback board
- At least 1 powerSPIN board (Eval 6205 / Eval 6235)
- At least 1 BLDC or 1 DC motor (respectively to be used with Eval 6205 or Eval 6235)
- eMotion firmware

5.1.1 Installing eMotion GUI

To install the eMotion GUI, launch the setup file named *eMotion_GUI_XX_Setup.exe*. After the acceptance of the license agreement, a new menu item (STMicroelectronics \ eMotion) will be created; use this link to launch the software.

The eMotion software is compatible with the Windows XP OS.

5.1.2 Board configuration

MDK-ST10:

ST10 FLASHING: The first operation to perform, before starting to use eMotion kit, is to flash ST10 microcontroller with eMotion firmware; in order to achieve this task, ST10Flasher (V2.4B or above) software has to be used (i.e. a software windows compatible useful to program the internal flash of ST10).

Connect MDK-ST10 to PC via a RS232 straight cable and puts ST10 in BSL mode (turn on bit 5 of switch 3 and reset the board). Using ST10Flasher, load file named "emotion.hex" and perform the flashing of microcontroller, so turn off bit 5 of switch 3 and reset the board.

Now MDK-ST10 is ready to be used with eMotion kit (EA jumpers has to be switched to 1)

J206 jumpers: In order to use the power spin boards, J206 jumpers have to placed in "Practi" position.

VCC Practi X Jumpers: leave open the Jumper VCC Practi1,VCC Practi2 and VCC Practi3.

SW3: All OFF

SW5: CSSEL0 ON,CLK1 ON, all the remains bits OFF.

Feedback board:

Connect the feedback board to the four expansion connectors of MDK-ST10 (the connectors surrounding microcontroller).

The correct connection for incremental encoder of motors is shown in *Table 11*

Table 11. Feedback connector

MDK-Connector/ Motor Value	Feedback board connector
Motor on Practi 1 encoder A	Connector 1 (J3), Pin 1
Motor on Practi 1 encoder B	Connector 1 (J3), Pin 3
Motor on Practi 2 encoder A	Connector 1 (J3), Pin 5
Motor on Practi 2 encoder B	Connector 1 (J3), Pin 7
Motor on Practi 3 encoder A	Connector 1 (J3), Pin 9
Motor on Practi 2 encoder B	Connector 1 (J3), Pin 11

The use of a flat cable is recommended to keep the signals shielded.

Eval 6205 configuration:

JP1: Place JP1 in the INT position to enable the on-board 5VDC supply.

JP2 and JP3: Install JP2 and JP3 to assure proper timing operation of the L6205's internal high side overcurrent protection.

JP4 and JP5: Install JP4 and JP5 to configure the Vref circuits.

Supply the power to eval 6205 through connector CN1.

Connect the DC motor through CN3 connector (OUT1A and OUT2A).

Refer to the *L6205 datasheet* for more detailed information

Note: For each EVAL 6205 board eMotion kit allows to connect and control one motor.

Eval 6235 configuration:

JP1 and JP2: Install JP1 and JP2 to enable the on-board 5VDC supply.

SWITCHES: Place all four switches in the OFF position.

HALL SENSORS: Connect the Hall sensors of the BLDC motor at CN5. Connect the power supply wires from the Hall sensors at pins GND and 5V. Connect H1, H2, and H3 signals to their respective pins.

Motor Connections: Connect the three motor armature wires at CN3 being careful to match the phasing to the Hall sensor connections.

Refer to L6235 datasheet for more detailed information.

To connect the power spin boards use a flat 34-pin cables and before power on all the systems (motors and boards) please refer to *Section 6.1: Hardware issues on page 26*.

5.1.3 Control operations

Before starting to use the motors, ensure that all the connection are correctly established.

Turn on MDK-ST10 and later turn the power of motors.

Open Loop

For a DC: enable the driver and modify the PWM in terms of DUTY % (depending on the motor connection, a 0 value corresponds to either the minimum or the maximum speed).

The direction of rotation depends on the connection of motor.

At startup the Duty cycle is fixed at 50 %

For a BLDC: enable the driver and unbrake the motor. Start to vary the PWM Duty %

At startup the Duty cycle is fixed at 50 %

Closed Loop

The parameter values of P, I and D depend on the type of motor and the suggestion is to start with lower values and increment them in order to reach better performance.

At low speeds it is recommended to use a high control loop time.

6 Limitations

This section provides tips for use of the eMotion system to avoid incorrect operation.

6.1 Hardware issues

Due to the sharing of some microcontroller configuration pins with the powerSPIN connectors (P0L.0 and P0L.1), the reset phase, when a L6235 evaluation board is connected through the "practi1" or "practi2" connectors causes the micro to enter "ADAPT" or "EMU" modes (when a pull-up is used).

A feature release (v 1.2) of MDK-ST10 will include a series of buffers to isolate these pins from connectors during the reset phase.

7 Revision history

Table 12. Document revision history

Date	Revision	Changes
30-Nov-2006	1	Initial release.

Appendix A Bibliography

- AN1794 *Application Note, "PractiSpin evaluation system configuration and setup guide"*.
- L6205 *datasheet*
- L6235 *datasheet*
- UM0288, *MDK-ST10 user manual*

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